METHODS FOR REFLECTION REDUCTIONS

RELATED APPLICATION

The present application claims the benefit of U.S. Provisional Application No. 60/048,998 filed June 9, 1997, which is fully incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates generally to minimization of reflections from surfaces, and more specifically reflections from objective lenses or other reflective surfaces of wide-angle field of view optical devices.

BACKGROUND OF THE INVENTION

Reflections from the objective lens or other reflective surfaces of an optical system (glint) have long been a problem, especially in a battlefield environment. These reflections turn out to also be a problem with wide-angle field-of-view (FOV) optics such as night vision goggles. This is especially so when operating in an environment where relatively bright ambient sources such as street lights are present, or in situations where the enemy also has night vision equipment and thus can see reflections of moon or starlight from an objective lens or reflective filter.

An existing method of reducing or eliminating such reflections is to put a honeycomb grid of tubes in front of the objective lens (as is described in U.S. Patent #4,929,055, which is fully incorporated herein by reference). The tubes in these devices have walls that are parallel to the optical axis of the device to which it is fitted.

This technique, however, is not an effective solution with wide angle FOV devices, since if the length-to-width ratio of the tubes which make up the honeycomb of parallel-walled tubes is shallow enough not to vignette the view through the optic, then the tubes are not deep enough to give affective glint protection. This means that in a battlefield situation, wide-angle FOV optical devices are vulnerable to being detected by an envoy, and thus dangerous to use.

Accordingly, it is highly desirable, if not necessary, to devise other techniques for substantially preventing reflections from the reflecting surfaces of wide-angle FOV optical devices.

As can be seen in FIG.1, a reflective element 1 of an optical device 2 can reflect light rays 5 from a light source 3 to an observer 4. The Observer 4 includes sophisticated light detection systems possibly operating in the infrared and ultraviolet spectrums as well as human or animal observers.

An existing method of hiding such reflections is shown in FIG 2. where a honeycomb of parallel-walled tubes 6 is placed in front of the optical device 2. The walls of the tubes are parallel to the optical axis of the device to which it is fitted. This collection of tubes 6 prevents light from a source 3 from reflecting to an observer 4.

As shown in FIG. 3, the length-to-width ratio of the tubes 12 that make up the honeycomb cannot exceed the length-to-width ratio of the FOV 13 of the optical device to which it is fitted. In this way, the anti-reflection shield does not restrict field of view seen through the optical device.

As shown in FIG 4, an example of this would be the U.S. Army's PVS-7 night vision goggles, which have a FOV 13 of 40°. If one were to use the existing method of reflection protection, the length-to-width ratio of the deepest (longest)

tubes 6 that could be used in a conventional anti-reflection shield are 1:1.38. This is not deep enough to give good glint protection. If deeper tubes are used, they would intrude on the FOV and vignette the image seen through the device, as illustrated in Fig. 5.

The problem has been how to get tubes long enough to provide effective glint protection without vignetting the view through the optic.

SUMMARY

It is an objective of the present invention to provide reflection and glint protection while allowing a wide field of view (FOV) for surfaces including optical lenses.

The present invention includes an apparatus for reducing reflection on a surface including a plurality of concentric circular vanes, each of the vanes including a first end proximate the surface. The second end of the plurality of vanes is away from the surface. The first ends of the plurality of vanes are positioned closer together to each other than said second ends of said plurality of vanes.

This surface includes optical lenses, wide FOV lenses, binoculars, telescopes, gun sights and night vision goggles.

In another embodiment, the first ends of the plurality of vanes are positioned further apart from each other than the second ends of the plurality of vanes.

In another embodiment, a plurality of radial vanes are interconnected with the plurality of concentric circular vanes.

The present invention includes a system and method for reducing reflection from a surface of an optical lens comprising vane means for limiting reflections from said surface while maintaining a substantially wide Field of View (FOV) for said optical lens. The vane means is for mounting proximate a surface of the optical lens.

DESCRIPTION OF THE DRAWINGS

The foregoing and other features and advantages of the present invention will be more fully understood from the following detailed description of illustrative embodiments, taken in conjunction with the accompanying drawings in which:

Fig. 1 is an overview of a reflection problem;
Fig. 2 is an overview of prior attempt to correct a reflection problem;
Fig. 3 provides details of the Field of View (FOV) of Fig. 2;
Fig. ~~4 provides details~~ of FOV angles;
Fig. 5 provides details of FOV angles;
Fig. 6 illustrates an embodiment of the present invention;
Fig. 7 details FOV angles for the embodiment illustrated in Fig. 6;
Fig. 8 and 9 illustrate details of optical image forming by convex lenses;
Fig. 10 illustrates a further embodiment of the present invention;
Fig. 11 details FOV angles for the embodiment illustrated in Fig. 10;
Fig. 12 illustrates a further embodiment of the present invention;
Fig. 13 illustrates a further embodiment of the present invention;
Fig. 14 illustrates yet another embodiment of the present invention; and
Fig. 15 illustrates yet another embodiment of the present invention.

DETAILED DESCRIPTION

In the novel technique, shown in one embodiment in FIG. 6, we describe a shield made up of deep tubes 32, the walls of which are not parallel, which is placed in front of a wide-angle FOV optic 33.

As shown in FIG. 7, this would seem to give a structure 32 that would vignette the FOV 13 seen through a wide-angle FOV optic 33; this actually is not the case.

As shown in FIG. 8, unlike the common explanation found in physics text books of how a lens forms an image, where this is shown by a drawing where a point 40 on the top of a lens 41 forms the image 42 of the top of the subject 43, such as a candle, and the point 45 at the bottom of the lens forms the image 47 of the bottom of the subject 48, what actually happens is shown in FIG. 9, where each point on the lens, as shown with point 51, forms the image 54 of the entire subject 53.

With this in mind, we describe a technique for protecting wide angle FOV optics from glint as shown in FIG. 10, wherein we arrange the cell walls 60 that make up the tubes of the antireflection shield such that the walls are parallel to the varying view angles 61 contained within the optic's FOV.

As shown in FIG. 11, while in such an arrangement a tube wall 66 would block a point 62 at the top of the lens from seeing on a viewing angle 65 downwards to the bottom part of its normal FOV, there is a point 67 at the bottom of the lens that would have an unobstructed view on the view angle 65 through the tube formed by wall 68. Thus with this new arrangement of tubes, the optical system will, in total, be able to maintain its full FOV in order to form a complete image, and the tubes in the shield can be made long enough to give effective glint protection.

These tubes can be arranged in various manners. For example, in a section through one embodiment of such a shield as shown in FIG. 12, the walls 60 could be arranged to form concentric tubes that have a conical section. These conical sections would be arranged so that their wall angles gradually

splayed to accommodate the range of viewing angles contained or thin the wide-angle FOV 71 of the optical device to be protected 33.

Alternatively, as shown in a section through another embodiment of such a shield in FIG. 13, the tube walls 60 could simply have one fixed angle and then be nested concentrically. The wall angles would be selected be related relation to the angle of the FOV of the optic that is to be protected 33. The center conical tube 77 would provide the clear sight lines to the center of the optic's FOV.

As shown in FIG. 14 in a section through yet another embodiment of such a shield, the walls that form the tubes 60 could splay inwards, rather than outwards.

As shown in a front view in FIG. 15, to increase the glint masking ability of this new configuration of an anti-reflection shield, radial vanes 83 can be inserted between the concentric tubes 60 in a manner.

This new technique of using non-parallel tube walls will give critical protection to wide-angle FOV optics on the battlefield.

Note that with this configuration, most points on the surface of the objective lens will have some of their lines of view blocked. This may cause a greater light loss than with the light loss from the earlier method of using a honeycomb of parallel-walled tubes. However, the increased light loss would be acceptable in many battlefield situations if this improved shield keeps the user of the optical device from being detected by the enemy because of reflections.

Further, with respect to the inwardly converging tubular elements as exemplified in FIG. 14, that tubular element configuration can provide the significant advantage of reducing reflections from a lens substrate that is

significantly curved. That is, the inwardly converging tubular elements can effectively capture reflections from such a curved lens surface.

Suitable tubular elements for use in accordance with the present invention are disclosed in U.S. Patent No. 4,929,055 and PCT/US93/11459, which are both fully incorporated herein by reference.

As various changes could be made in the above constructions without departing from the scope of the invention, it should be understood that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.